Overview
Mining Industry of the Future

Industrial Technologies Program
Energy Efficiency and Renewable Energy
www.oit.doe.gov/mining

Mike Eastman - Mining Team Coordinator
National Energy Technology Laboratory

DOE Organization

**Secretary
Spencer Abraham**

Nuclear Security/Administrator for National Nuclear Security Administration
- Defense Programs
- Defense Nuclear Nonproliferation
- Naval Reactors
- Emergency Operations
- Facilities and Operations
- Management and Administration

Energy, Science and Environment
- Environmental Management
- Fossil Energy
- Science
- Civilian Radioactive Waste Management
- *Energy Efficiency and Renewable Energy*
- Environment, Safety and Health
- Energy Science and Technology
- Worker and Community Transition

- Policy and International Affairs
- Congressional and Intergovernmental Affairs
- General Counsel
- Management Budget and Evaluation/CFO
- Energy Information Administration
- Economic Impact and Diversity
- Chief Information Officer
- Public Affairs
- Counterintelligence
- Intelligence
- Security
- Inspector General
- Independent Oversight and Performance Assurance
- Energy Advisory Board
- Hearing and Appeals
- Energy Assurance
- Representative to the DNFSB
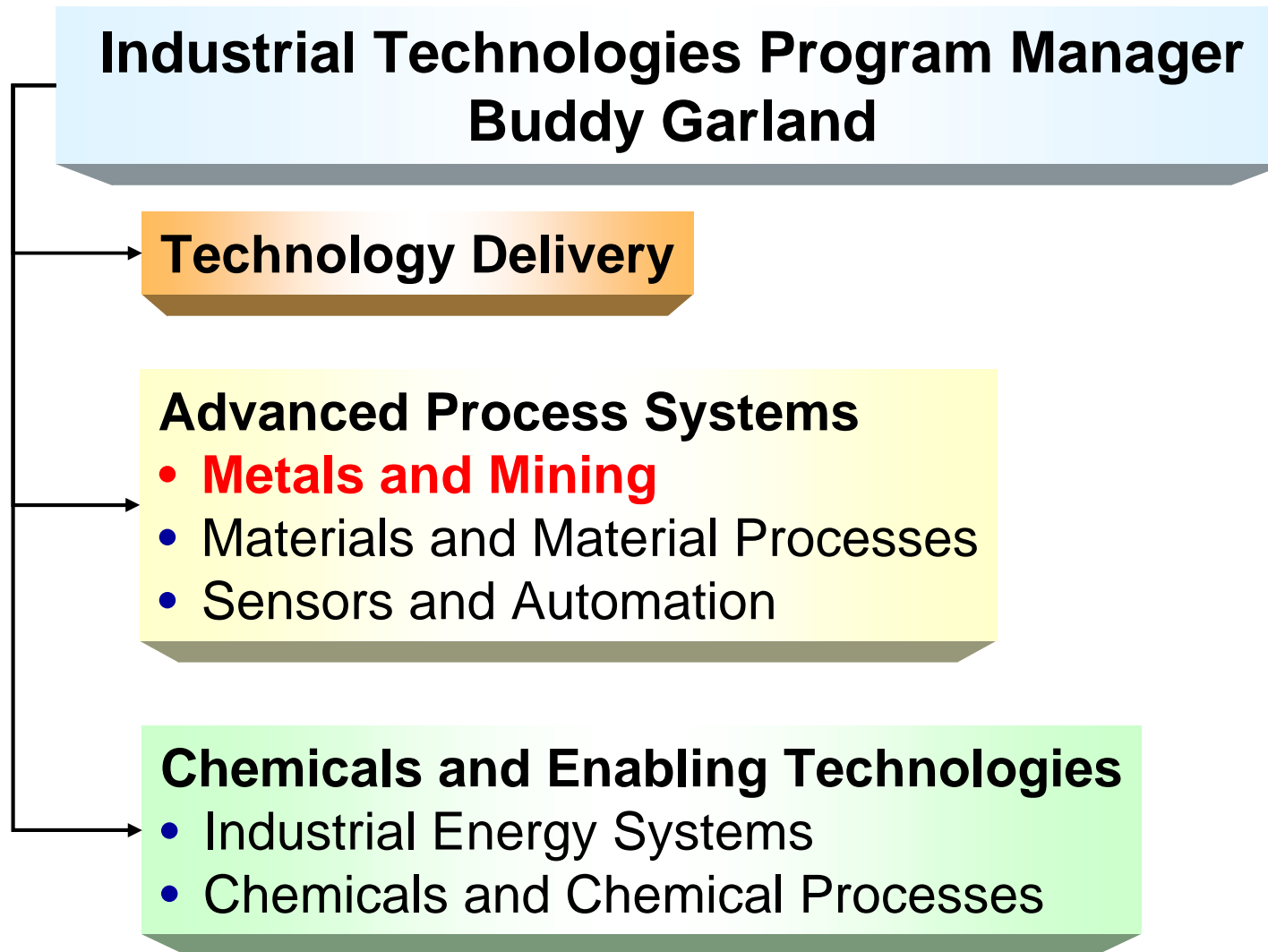- Power Marketing Admonitions

NETL

- Biomass

- Building Technologies

- Distributed Energy & Electric Reliability

- Federal Energy Management

- Freedom CAR & Vehicle Technologies

- Geothermal

- Hydrogen, Fuel Cells, & Infrastructure

- Industrial Technologies

- Solar

- Wind & Hydropower

- Weatherization & Intergovernmental

OIT Organization

Industrial Technologies Program Manager
Buddy Garland

Technology Delivery

Advanced Process Systems
- **Metals and Mining**
- Materials and Material Processes
- Sensors and Automation

Chemicals and Enabling Technologies
- Industrial Energy Systems
- Chemicals and Chemical Processes

Mining Industry Vision
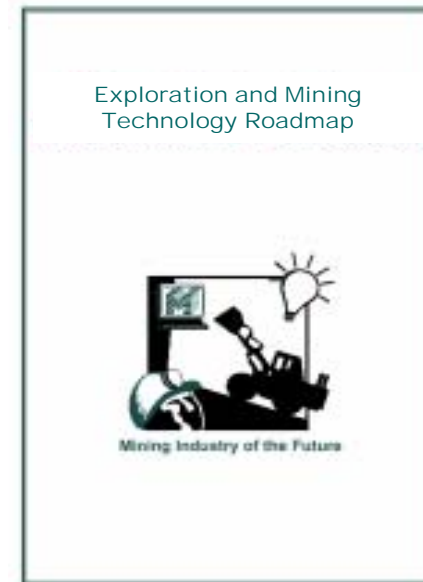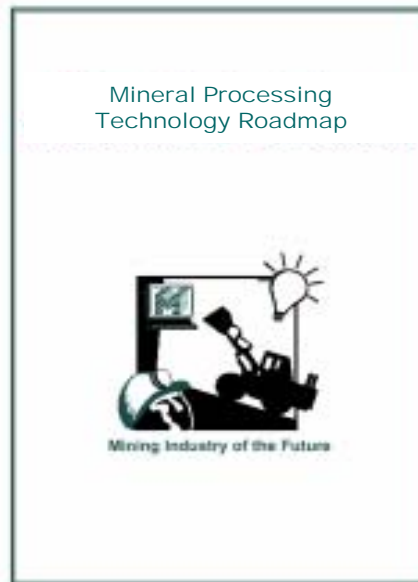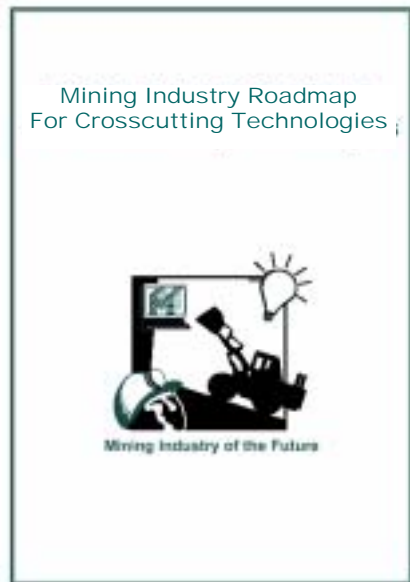
Vision Goals (9/1998)

- Low-cost and Efficient Production

- Superior Exploration and Resource Characterization

- Safe and Efficient Extraction and Processing

- Responsible Emission and By-Product Management

- Advanced Products

- Positive Partnership with Government

- Improved Communication and Education

Roadmap R&D Areas

Targeted Roadmaps

- Crosscutting Technologies Roadmap (2/1999)

- Mineral Processing Technologies Roadmap (9/2000)

- Exploration and Mining Technologies Roadmap (9/2002)

Mining Industry Roadmap
For Crosscutting Technologies

Mining Industry of the Future

Mineral Processing
Technology Roadmap

Mining Industry of the Future

Exploration and Mining
Technology Roadmap

Mining Industry of the Future

Evolution of Mining IOF

Original IOF
Vision/Roadmaps set stage for successful partnerships and broad based R&D
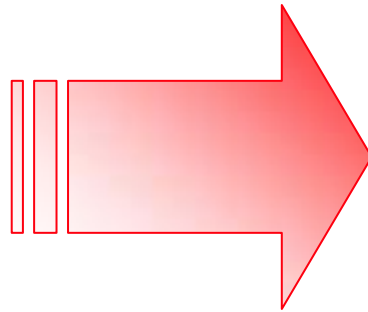
Outlook
Solid partnerships Transition to high-impact, high-value R&D. An industry "Grand Challenge"

Outlook for the Mining Industry of the Future

Mining IOF organized energy intensive processes around its portfolio.

- **Extraction** - equipment/processes used to search for and dig ore and waste.

- **Materials Handling** - equipment/ processes used to transport ore and waste.

- **Beneficiation and Processing** - equipment/processes used to separate, concentrate and/or refine ore from unwanted material.

Energy Consumption in Mining by Stage

Materials Handling 42%

Beneficiation & Processing 39%

Extraction 19%
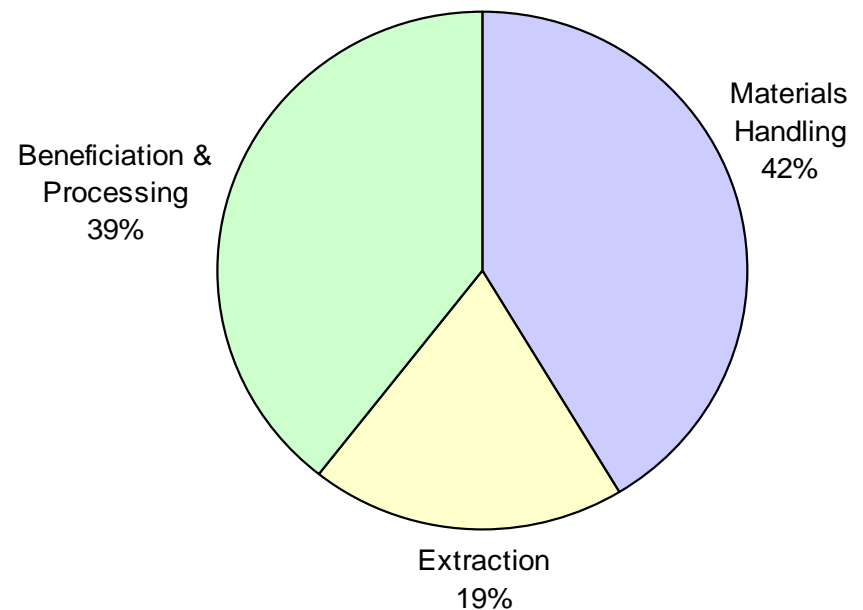
Beneficiation and Processing

- Dense Medium Cyclone Optimization
- Calibration Methods for On-line Analyzers
- Mining By-product Recovery
- Selective Flocculation of Fine Mineral Particles
- Alternate Anodes
- Smart Screening
- Novel Dewatering Aids for Mineral and Coal Fines
- Treatment of Cyanide Solutions and Slurries Using ASH Technology
- Three-Dimensional Simulation of Charge Motion in SAG and Ball Mills for Energy Efficiency
- Comminution Circuit Optimization
- Mine Compatible Laser Analysis Instrument for Ore Grading
- Real-time Coal/Ore Grade Sensor

**Current Mining IOF R&D Portfolio
(Percent of Funding)**

Beneficiation & Processing 31%

Materials Handling 34%
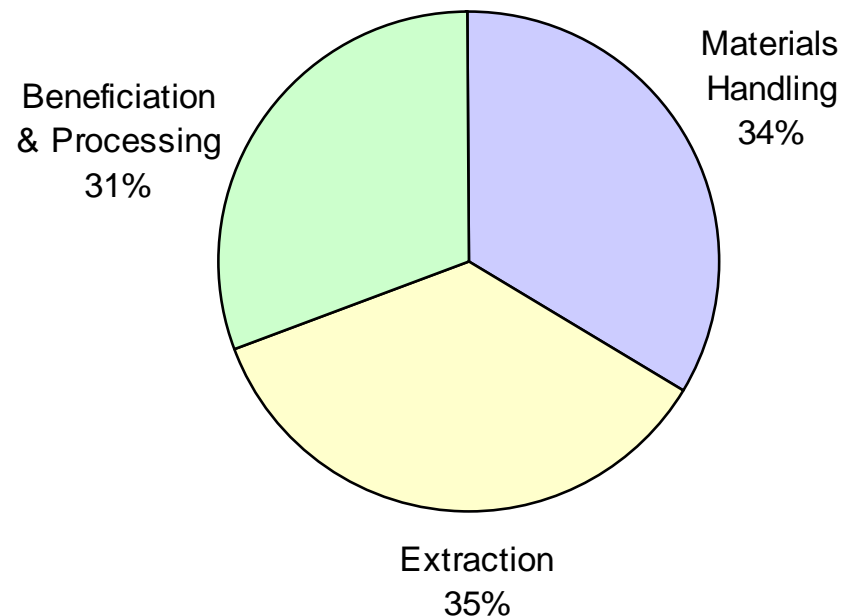
Extraction 35%

Current Research (continued)

Extraction

- Horizon Sensing
- Imaging Ahead of Mining
- 24-Channel Geophone Array for Horizontal or Vertical Boreholes
- Mapping with Natural Induced Polarization
- Robotics Technology for Improving Mining Productivity
- Drilling and Blasting Optimization
- Computerized Roof Bolt Design System
- Projectile Based Excavation
- High Temperature Superconductors in Underground Communications
- Wireless Mine-Wide Telecommunications Technology

Materials Handling

- Fibrous Monolithic Composites as Wear Resistant Components for Mining
- Advanced Processes for Abrasion Resistant Metal-Matrix Composites and Thermal Spray Coating for Earth Moving Machines
- Hydride Fuelcell for Mining Vehicles
- Advanced Power and Control for Fuel Cell Vehicles
- CastCon Processes for Mining Applications
- Development and Deployment of Automated Machine Fluid Analysis Systems

Focus for Grand Challenge

Analysis of equipment-level energy use identified opportunities for energy efficiency

- ◆ Reduce energy consumption in Materials Handling
  - Diesels accounts for 87% of energy used in Materials Handling
  - Target – develop alternatives to diesel technologies
- ◆ Reduce the energy consumption in Beneficiation & Processing
  - Comminution activities account for 75% of energy used in Beneficiation & Processing
  - Target – develop energy efficient alternatives to current comminution processes
- ◆ Reduce the energy consumption and increase recovery efficiencies in Extraction
  - Improvements in Extraction will reduce energy use in Materials Handling & Beneficiation and Processing: Target improve Extraction efficiencies
  - Pumps account for 41% of Extraction: Target – develop alternatives to pumps

Current Research Partners

Primary Research Performers

1. Advanced Ceramics Research, Inc.
2. Advanced Power Technologies, Inc.
3. AdvR, Inc.
4. Caterpillar Inc.
5. Electromagnetic Instruments, Inc.
6. Fuel Cell Propulsion Institute
7. Minerals and Coal Technologies Inc.
8. Stolar Horizon, Incorporated
9. Transtek, Inc.
10. Albany Research Center
11. Argonne National Laboratory
12. Idaho National Engineering and Environmental Laboratory
13. Lawrence Berkeley National Laboratory
14. Los Alamos National Laboratory
15. Oak Ridge National Laboratory
16. Pacific Northwest National Laboratory
17. Sandia National Laboratory
18. Savannah River Technology Center
19. Michigan Technological University
20. QRDC
21. The University of Alaska
22. Virginia Polytechnic Institute and State University
23. West Virginia University
24. University of Utah
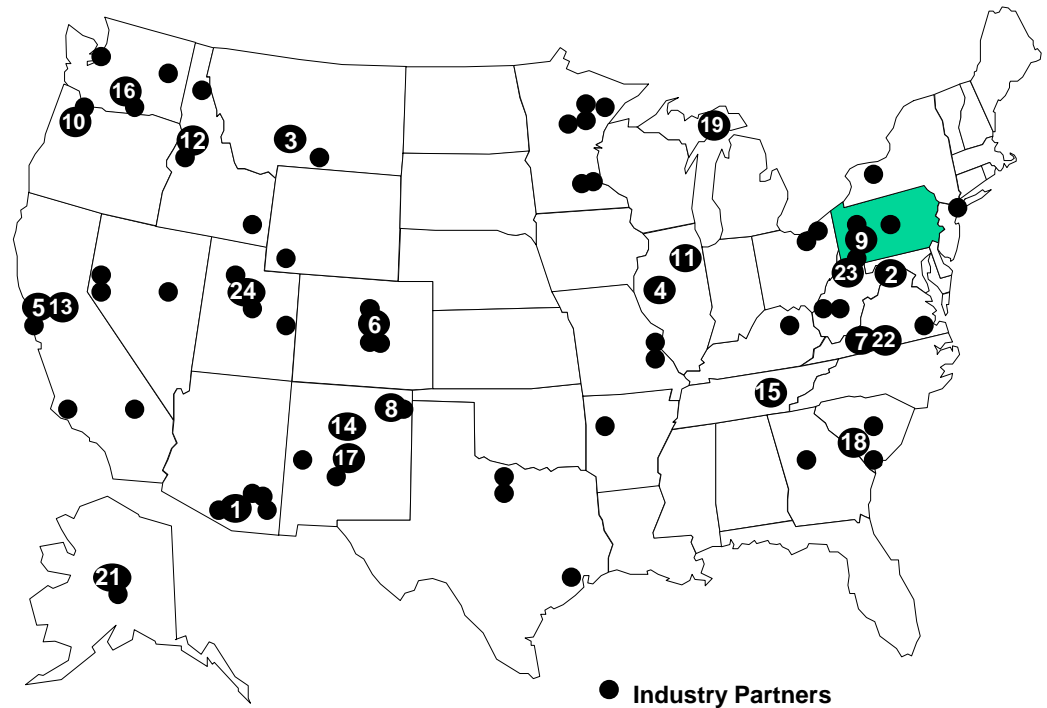
● Industry Partners

The Mining Industry of the Future is currently funding 28 cost shared projects with 151 project partners including 141 from industry and academia.

Wireless Mine-Wide Telecommunications

Remote Interface stations like the one above is similar to the wireless communication stations.

Objective

- To develop a two-way, real-time, wireless communications system for use in underground mines. This technology will lower the cost of mining by increasing productivity as well as increase the safety of miners.
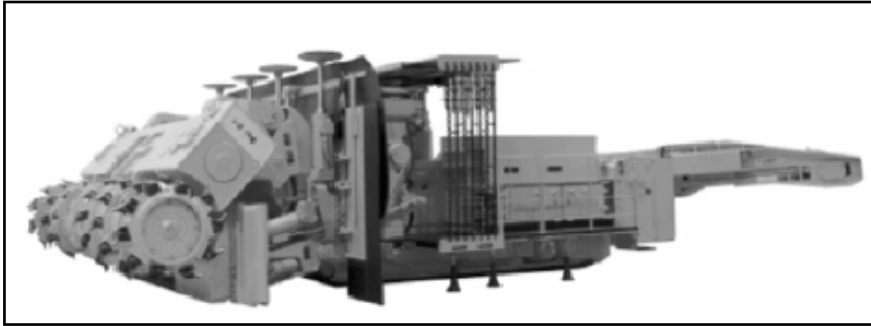
Transtek, Inc., Pittsburgh, PA
University of Pittsburgh, Pittsburgh, PA
Victor Products USA, Cranberry Twp, PA

National Institute for Occupational Safety and Health, Pittsburgh, PA
CONSOL, Inc., Library, PA
Gateway Commerce Center, Wampum, PA

Robotics Technology for Improving Mining Productivity

Sensors will be placed on a continuous mining machine to measure the machine's position, orientation, and motion.

Objective

- To use advanced sensors mounted on underground mining equipment to increase the precision of material removal and thus reduce re-cuts and reduce the amount of energy used in hauling and excavating materials.
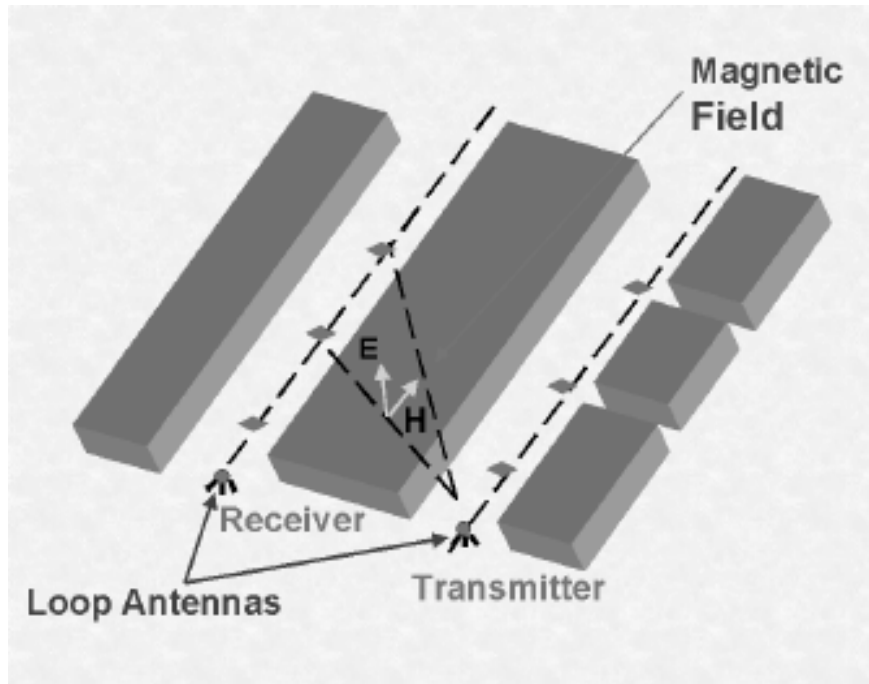
Idaho National Engineering and Environmental Laboratory, Idaho Falls, ID

CONSOL Inc., Library, PA

Joy Mining Machine, Franklin, PA

Carnegie Mellon University, Pittsburgh, PA

Imaging Ahead of Mining

Magnetic Field

E

H

Receiver

Loop Antennas

Transmitter

RIM transmits electromagnetic waves on one side of the geologic target and uses a receiver on the other side to collect data about the geologic mass.
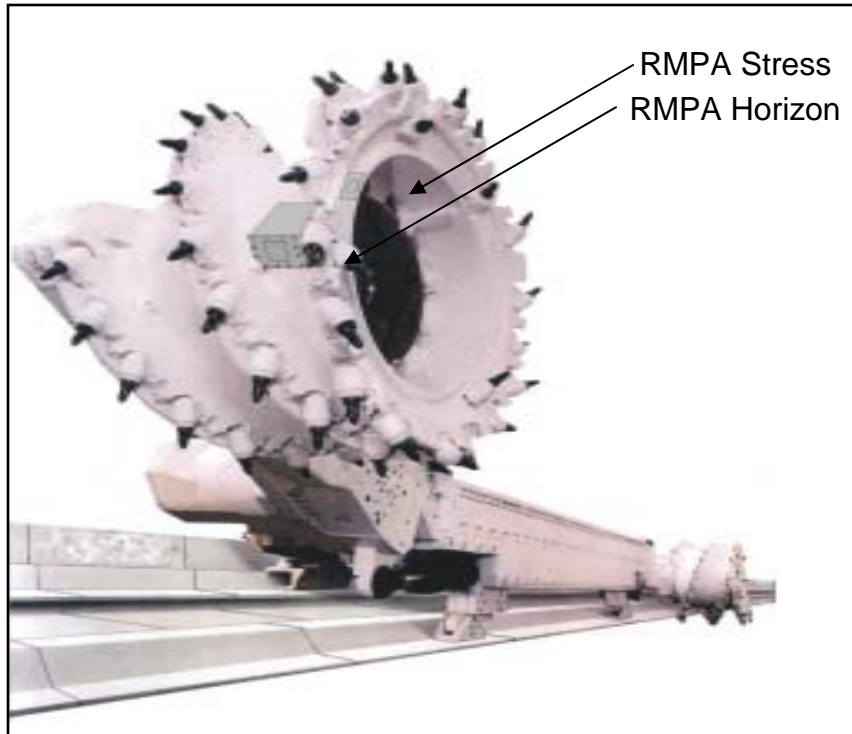
Objective

- To use the Internet, instrumentation advances, and newly developed modeling and analysis software to accurately image the volume of material ahead of mining, thereby improving the quality of mined ore, reducing wear of mining machinery, facilitating mine operations, and reducing costs.

Sandia National Laboratories, Albuquerque, NM

CONSOL Inc., Library, PA

Stolar Horizon, Incorporated, Raton, NM

West Virginia University, Morgantown, WV

Kennecott Exploration, Salt Lake City, UT

Horizon Sensing™

RMPA Stress
RMPA Horizon

Proposed mounting of RMPAs and explosion-proof enclosure on shearer drum.

Objective

- To test remote sensing and imaging technology on the cutting edges of mining equipment to make real-time measurements of mining conditions. Researchers hope to develop a cutting-edge sensor that will improve worker safety by preventing mining into high-pressure water/carbon dioxide cavities, and by allowing greater remote control of equipment while improving the efficiency of mining operations.
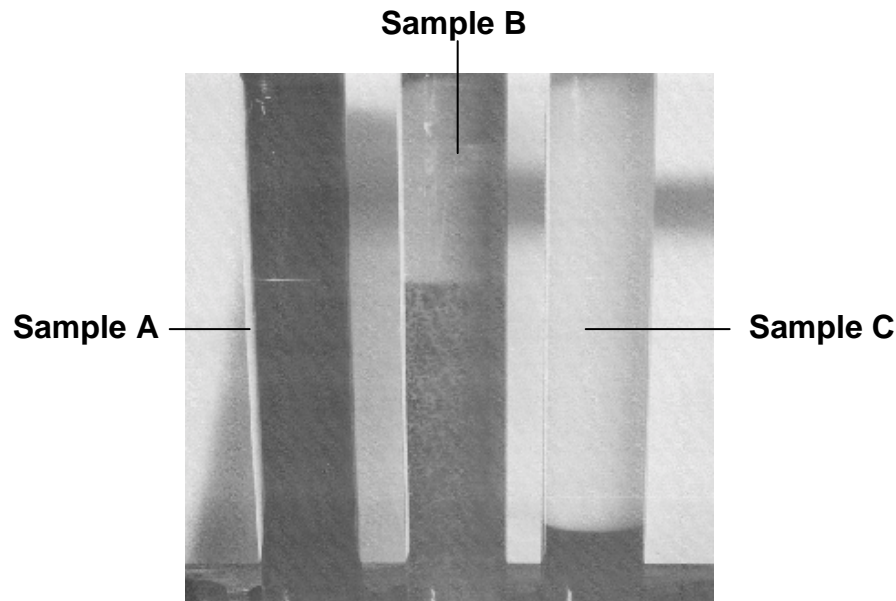
Stolar Horizon, Inc., Raton, NM
Colorado School of Mines, Golden, CO
Los Alamos National Laboratory, Los Alamos, NM
Mine Safety and Health Administration, Pittsburgh, PA

CONSOL, Inc., Library, PA
RAG American Coal, Price, UT
FMC Corporation, Green River, WY
Lee Ranch Coal Co., Grants, NM

Sample B

Sample A

Sample C

Selective flocculation may be used to separate two or more finely divided minerals in a dilute slurry. With appropriate reagents under the right conditions in the dispersed slurry (sample A), one of the constituents flocculates (dark aggregates in the bottom of sample B) and settles or is otherwise separated from the unflocculated constituents that remain in suspension (sample C).

Selective Flocculation of Fine Mineral Particles

Objective

- Develop successful selective flocculation technologies that will enable recovery of ultra fine size minerals and coal currently lost in tailings.

Albany Research Center, Albany, OR
J.R. Simplot Company, Pocatello, ID
Peabody Energy, St. Louis, MO
Florida Institute of Phosphate Research, Bartow, FL

University of Kentucky, Lexington, KY
Pennsylvania State Univ., University Park, PA
University of Idaho, Moscow, ID
Ciba Specialty Chemicals USA, Suffolk, VA

NETL

Computerized Roof Bolt Design System

The system will help improve roof bolting operations such as this one shown above.

Objective

- To improve roof-bolting techniques, the most popular method for supporting roofs in underground mines. A computerized roof-bolting control system that can evaluate the geologic conditions of a roof in real-time will be developed to determine suitable roof bolt system design requirements. Improvements in roof-bolting systems will lead to increased worker protection and mining production.

West Virginia University, Morgantown, WV
CONSOL Inc., Library, PA
Commercial Stone Co. Inc. Connellsville, PA
The Ohio Valley Coal Co., Alledonia, OH

J.H. Fletcher & Co., Huntington, WV
Newmont Mining Co., Denver, CO
Riverton Coal Production Inc., Charleston, WV

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Novel Dewatering Aids for Mineral and Coal Fines

Pilot-scale disc filter used for dewatering tests.

Objective

- To develop novel chemicals used in conjunction with conventional mechanical dewatering equipment so that water can be removed more efficiently. The use of the reagents will not only allow mining com-panies to recover the fines that are currently being discarded, but also help them recover valuables from waste impoundments.
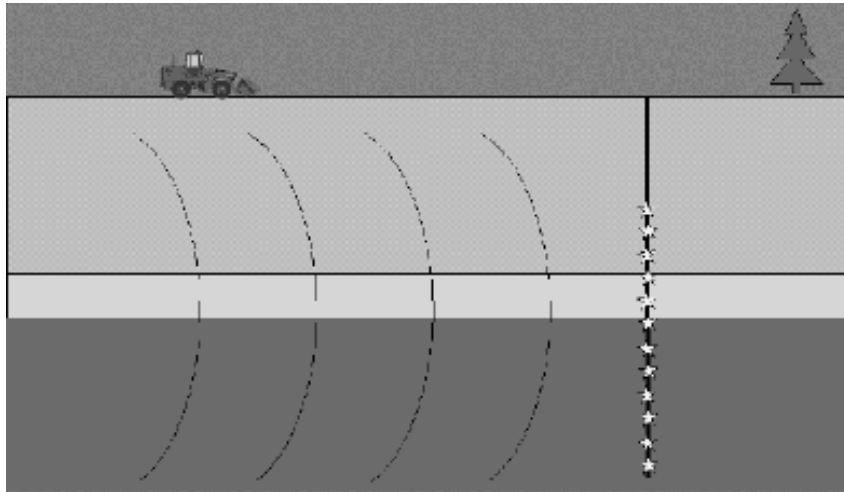

Minerals and Coal Technologies, Inc., Blacksburg, VA
Peterson Filters Corporation, Salt Lake City, UT

Beard Technology, Inc., Pittsburgh, PA
Boliden AB, Boliden, Sweden

24-Channel Geophone Array for Horizontal or Vertical Boreholes

Above illustration shows seismic sensors in dry a vertical borehole for surface mining/quarrying.

Objective

- To develop an array of 24 seismic sensors capable of being mounted in either vertical or horizontal bore-holes to improve ground-imaging techniques. This will reduce energy usage in mining operations because anomalous conditions ahead of mining will be more clearly imaged, allowing fewer interruptions and less waste material mined.

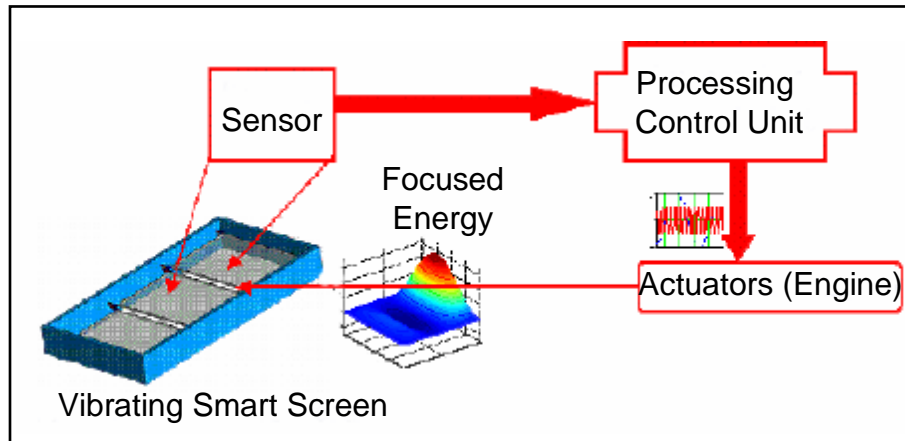*Virginia Tech, Blacksburg, VA*
CONSOL Inc., Library, PA

Global Stone James River, Buchanan, VA
NSA Engineering, Inc., Golden, CO

NETL

Smart Screening Systems for Mining

Conceptual design of a closed loop control system for a Smart Screen System.

Objective

- To develop a Smart Screening System that reduces energy us in screening processes by 75%. In addition, Smart Screening Systems will reduce maintenance requirements, improve throughput, and increase work safety and health.

Albany Research Center, Albany, OR
QRDC, Chaska, MN
Minnesota Technology, Inc., Minneapolis, MN
U.S. Steel-MINNTAC, Mt. Iron, MN

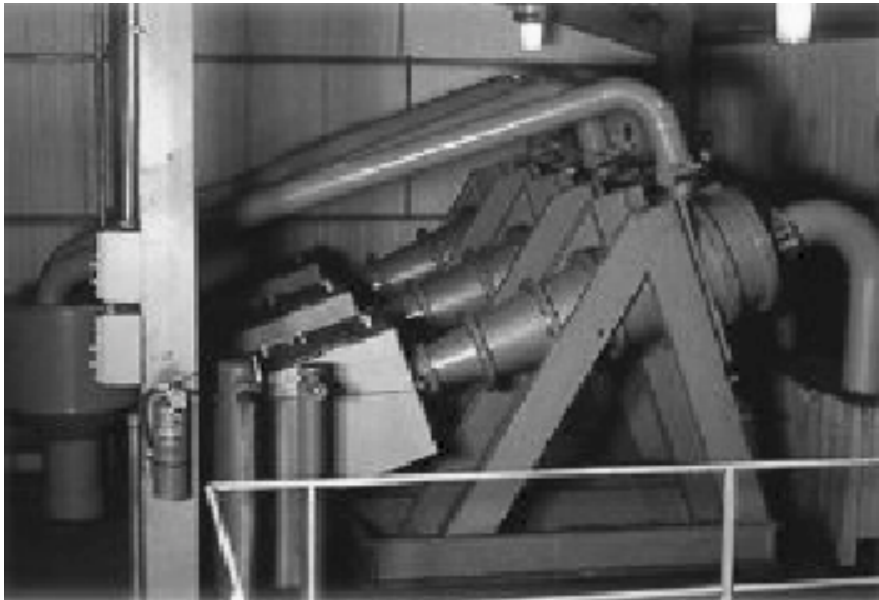*Inland Mining, Virginia, MN*
UEC Technologies LLC, Pittsburgh, PA
Smart Screen Systems, Inc., Chisholm, MN

Dense-Medium Cyclone Optimization

Bank of three DMCs in operation at a coal preparation plant.

Objective

- To develop a set of engineering tools that will improve the efficiency of dense-medium cyclones used to separate coal or minerals from waste rock. These improvements will reduce the energy costs associated with the process and increase the amount of valuable materials that are recovered as product.

Other Opportunities

- **Participate in Future Solicitations**
  - http://www.oit.doe.gov/news/solicitations.shtml

- **Inventions and Innovation**
  - www.oit.doe.gov/inventions

- **Mining IOF Grand Challenge Workshops**
  - July 21, 2003 Pittsburgh area -- http://www.oit.doe.gov/mining

- **BestPractices**
  - www.oit.doe.gov/bestpractices
  - July 22-23, 2003 Pittsburgh area (pumps and motors)

- **DOE-SBIR** (annually)
  - http://sbir.er.doe.gov/sbir